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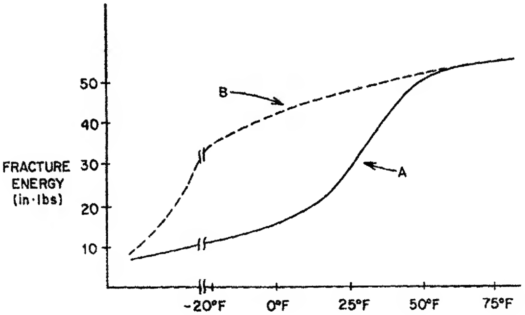

(57) Abstract

A microcellular article is provided for storage in a freezer and/or for use in cooking food in an oven. The article can be in the shape of a container with a cover, for example a container for frozen food item that can be stored in a freezer, removed from the freezer and placed in a conventional or microwave oven, and used to cook the food in the oven. The container can include a lid that sealingly engages the container, or a plastic cover, such as a clear plastic cover typical of frozen dinner containers that sealingly engages the rim of the container opening.

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MICROCELLULAR FOOD CONTAINER AND METHOD FOR STORING FOOD IN SUCH A CONTAINER

Field of the Invention

The present invention relates generally to food containers, and more particularly to food containers made of microcellular polymeric material.

Background of the Invention

Food storage containers, in particular polymeric food storage containers, enjoy phenomenally widespread use. Trays, plates, bowls, and other food containers with and without lids or other covers have been made from a variety of polymeric materials, for use in the packaging of pre-prepared food products, either frozen, refrigerated, shelf-stable, or fresh. An increasingly-successful class of food storage containers include those filled with pre-prepared food items for cooking or heating in a microwave or conventional oven. Food stored and sold in such containers typically must be kept frozen, or at least refrigerated prior to use.

Polymeric food storage containers should have good impact strength for several reasons. First, if the containers are dropped, it is, of course, best if they do not break. Additionally, since the containers are expected to perform well across a wide range of temperatures, and under conditions in which temperature changes drastically and rapidly, the container should have very good impact properties over the temperature range within which the container is used.

Typically, the impact properties of polymeric materials at low temperatures are reduced relative to those properties at higher temperatures. Polymeric materials include a well-known characteristic "brittle/ductile transition temperature" at which the energy absorbed before fracture (fracture energy) changes markedly. The brittle/ductile transition temperature is a temperature (typically a narrow range of temperature) above which impact properties are relatively good (e.g. the material is ductile) and below which impact properties are markedly poorer (e.g. the material is brittle). That is, impact properties typically become poorer, gradually, as temperature drops, but become much poorer, very quickly, at a particular brittle/ductile transition temperature. Brittle/ductile transition temperatures for most polymers absent auxiliary impact modifiers fall within (or are above) a temperature range at which food is desirably stored. Accordingly, impact modifiers such as rubber particles typically are added to polymeric food storage containers, adding processing steps and related cost.

Foamed polymeric materials are known, and typically are produced by providing a chemical or a physical blowing agent into a molten polymeric stream, mixing the blowing agent with the polymer, and extruding the mixture into the atmosphere while shaping the mixture. Exposure to atmospheric conditions causes the blowing agent to expand and to form cells in the polymer. Batch processes, that is, those in which a batch of material is treated to make a foam, rather than continuous treatment of a stream of material, are known.

It is generally accepted that foaming polymeric materials raises their brittle/ductile transition temperature. Thus, it would be expected that foamed materials would exhibit poor low temperature impact properties.

Microcellular material is defined as cell-containing material of very small cell size. U.S. Patent No. 4,473,665 (Martini-Vvedensky, et al.; September 25, 1984) describes a process for making foamed polymer having cells less than about 100 microns in diameter. In the described technique, a material precursor is saturated with a blowing agent, the material is placed under high pressure, and pressure is rapidly dropped to nucleate the blowing agent and to allow the formation of cells. The material then is frozen rapidly to maintain a desired distribution of microcells.

U.S. Patent No. 5,158,986 (Cha, et al.; October 27, 1992) describes formation of microcellular polymeric material using a supercritical fluid as a blowing agent. In a batch process of Cha, et al., a plastic article is submerged in supercritical fluid for a period of time, and then quickly returned to ambient conditions. In a continuous process, a polymeric sheet is extruded, then run through rollers in a container of supercritical fluid at high pressure, and then exposed quickly to ambient conditions. In another continuous process, a supercritical fluid-saturated molten polymeric stream is established. The stream is rapidly heated, and the resulting thermodynamic instability (solubility change) creates sites of nucleation while the system is maintained under pressure preventing significant growth of cells. The material then can be injected into a mold cavity where pressure is reduced and cells are allowed to grow.

Summary of the Invention

The present invention is based upon the applicants' surprising discovery that formation of an article such as a polymeric article into a microcellular article significantly decreases the ductile/brittle transition temperature of the article relative to the article as unfoamed, whether or not it includes an impact modifier.

Accordingly, one aspect of the invention involves a series of methods for food storage. In one embodiment, the invention provides a method in which food is stored in a microcellular article at a temperature of less than about 40°F. The food is stored at this temperature for a period of time of at least about one hour. In another embodiment, the storage temperature is less than about 32°F, and in another less than about 20°F. The period of time of such storage can be increased to at least one day, or longer in accordance with the invention. This set of methods embraces a variety of useful food storage conditions across a temperature range at which higher-then-expected impact properties of the polymeric container are observed.

According to another aspect, the invention provides a series of articles for food storage. In one embodiment, the invention provides a microcellular article in the shape of a container with an opening in combination with a cover fitted to the opening. The cover can be one of a variety of types, as described in greater detail below. The article can also include instructions for storage of food in the article.

In another embodiment, the invention provides a microcellular container in combination with instructions for storage of food in the container.

Another embodiment provides a microcellular article in combination with instructions for storage of the article in a freezer. This embodiment takes advantage of the improved low-temperature impact properties of microcellular material for essentially any purpose.

Other advantages, novel features, and objects of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing.

Detailed Description of the Invention

Commonly-owned U.S. provisional patent application serial no. 60/024,623, entitled "Method and Apparatus for Microcellular Extrusion", filed August 27, 1996 by Burnham, et al.; commonly-owned U.S. provisional patent application serial no. 60/026,889 entitled "Method and Apparatus for Microcellular Extrusion", filed September 23, 1996 by Kim, et al.; Commonly-owned U.S. patent application serial no. 08/777,709, entitled "Method and Apparatus for Microcellular Extrusion", filed December 20, 1996 by Burnham, et al.; International Patent Publication no. WO 98/08667 by Burnham, et al., published March 8, 1998, entitled "Method and Apparatus for Microcellular Extrusion"; and commonly-owned U.S. provisional patent application serial no. 60/035,631, entitled "Injection Molding of

Microcellular Material", filed January 16, 1997 by Anderson, et al., all are incorporated herein by reference.

As noted above, the present invention is based upon the applicants' discovery that a microcellular polymeric article shows surprisingly good ductile behavior at low temperature. Fig. 1 is a representation of a shift in ductile/brittle transition temperature to lower temperature that is illustrative of characteristics of microcellular material, as discovered in accordance with the present invention. Fig. 1 is a graph plotting fracture energy as a function of temperature. Curve A is representative of solid, impact-modified polyethylene terephthalate as described below in example 1. The hypothetical material representing curve A, above a temperature of approximately 40-50°F, exhibits good fracture energy on the order of 50 in·lbs. At approximately 40-45°F, however, the fracture energy begins to drop significantly as temperature drops, reaching an approximate plateau approaching 10 in·lbs below about 25°F. The portion of the curve of steepest slope, indicating significant drop in impact properties as temperature is lowered, represents the ductile/brittle transition temperature of the material. This material, at freezer temperature, will not exhibit ideal impact properties.

Curve B is representative of a microcellular article, in particular a microcellular polymeric article, of the invention with or without auxiliary impact modifier. The ductile/brittle transition temperature, characterized by the steepest portion of the curve, is shifted dramatically to a temperature lower than approximately -20°F, as illustrated. Above this temperature the material exhibits good impact properties approaching or better than 40-50 in·lbs., and impact properties are not reduced to the area approaching 10 in·lbs. until the temperature reaches a temperature that is below, perhaps significantly below, 20°F. This material, when used as a freezer storage container, exhibits good impact properties in the range about 40 in·lbs.

Fig. 1 does not reflect, precisely, data obtained experimentally, but is an illustrative representation of the shift in ductile/brittle transition temperature demonstrated by the examples below. Based upon the examples below it is demonstrated that the ductile/brittle transition temperature is shifted to lower temperature for microcellular material, in particular to temperatures below those typically used in freezing food, but it has not been determined how low the ductile/brittle temperature is shifted. That is, the shift to a temperature below -20°F, as illustrated in Fig. 1, may be to a temperature below 0°F, perhaps well below 0°F.

For purposes of the present invention, microcellular material is defined as foamed

material containing cells of size less than about 100 microns in diameter, or material of cell density of generally greater than at least about 10^6 cells per cubic centimeter, or preferably both. Supermicrocellular material is defined for purposes of the invention by cell sizes smaller than 1 μm and cell densities greater than 10^{12} cells per cubic centimeter. Ultramicrocellular material is defined for purposes of the invention by cell sizes smaller than 0.1 μm and cell densities greater than 10^{15} cells per cubic centimeter.

In preferred embodiments, microcellular material of the invention is produced having average cell size of less than about 100 microns, more preferably less than about 25 microns, more preferably less than about 25 microns, and more preferably still less than about 6 microns. The microcellular material preferably has a maximum cell size of about 100 microns, preferably about 30 microns, more preferably about 15 microns. A set of preferred embodiments includes all combinations of these preferred average cell sizes and maximum cell sizes. That is, a preferred embodiment in this set of embodiments includes microcellular material having an average cell size of less than about 10 microns with a maximum cell size of about 30 microns, in a more preferred embodiment an average cell size of less than about 6 microns with a maximum cell size of about 15 microns, etc.

The void fraction of microcellular material of the invention generally varies from about 5% to about 98%. In preferred embodiments the void fraction is less than about 85%, which can be characteristic of sturdy, well self-supporting material that provides a food container with a feel of durability more suitable for consumer use involving, for example, thawing and heating, re-freezing, re-heating, etc. This is in contrast to higher void fraction materials (typically greater than 85% void fraction) such as meat trays that are designed typically for a single use involving only thawing, and that do not have a look and feel desirable for serving food, even on an informal basis. In this set of embodiments, the void fraction of the microcellular article of the invention preferably is less than about 75%, more preferably less than about 60%, and more preferably still less than or equal to about 50%. Lower void fraction also provides stiffness to an article without increasing thickness, making an article more suitable for use as a plate or bowl out of which to eat food directly.

In one embodiment, essentially closed-cell microcellular material is produced. As used herein, "essentially closed-cell" is meant to define material that, at a thickness greater than of about 200 microns, contains no connected cell pathway through the material.

In preferred embodiments of the invention polymeric microcellular articles are

provided for low-temperature use. Homopolymers, copolymers, and/or blends can be used, preferably thermoplastic polymeric material with relatively high heat resistance such as PET, polypropylene, high impact polystyrene, maleic anhydride co-polystyrene (e.g. DYLARK™), and the like, optionally including additives. Specifically, polyester polymers are useful including polyesters derived from dibasic acids containing from about 6 to about 40 carbon atoms and glycols containing from about 2 to about 10 carbon atoms, generally crystallizable. Preferred dibasic acids for preparing polyesters include terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid, cyclohexanedicarboxylic acid and the like or their alkyl esters. Preferred dibasic acids, glycols, and polyester copolymers are described in U.S. Patent No. 5,482,977 (McConnell), incorporated herein by reference. These polyesters and copolymers and blends thereof can readily be made by those of ordinary skill in the art using conventional techniques. The polymeric article can contain additives such as olefins including acids, esters, anhydride-modified olefins, polycarbonates, impact modifiers, colorants, nucleating agents, mold-release-agents, grafting and cross-linking agents, heat stabilizers, and the like. Use of these additives is known, as described in U.S. Patent No. 5,322,663 (Lai), incorporated herein by reference. Other polymeric materials, such as thermoset materials can be used. Polymeric materials such as those described in International Patent Publication no. WO 98/08667 of Burnham, et al., U.S. patent application serial no. 08/777,709, referenced above, and co-pending, commonly-owned provisional application serial nos. 60/030,731 and 60/035,631, and U.S. Patent Nos. 5,334,356, 5,160,674, 5,158,986, and 4,473,665, all incorporated herein by reference, can be used.

A variety of techniques for forming microcellular material can be used in connection with the invention, including those disclosed in the above-referenced applications of Burnham, et al., Kim, et al., and Anderson, et al., as well as those disclosed in U.S. Patent Nos. 5,158,986, 4,473,665, and 5,160,674, each incorporated herein by reference. That is, the articles of the invention can be injection molded in final form, can be extruded as a sheet and thermoformed into a final shape, or the like. The particular technique used to form the articles of the invention is not important, as long as microcellular material results.

In one embodiment the invention provides a method of storing a microcellular article at relatively low temperature, such as in a freezer. This means that the article is stored at a temperature of less than about 40°F, typically less than about 32°F, preferably at or less than about 20°F, more preferably less than about 10°F, and more preferably still less than about

5 °F. The article can be a food container including an opening for receiving food and, optionally, can include a lid. The container can be stored with food at these temperatures, and the container with or without food preferably is store at one of these temperatures for a period of time of at least about 1 hour, more preferably at least about 1 day, or other times as indicated below.

The method embraces storage of an article that is not a food-storage container in a freezer, such as an ice tray, a portable ice storage container such as those that are designed to permanently contain a high-specific-heat fluid, or a fluid which requires much energy to thaw, such as are stored in freezers overnight and carried in lunch boxes during the day to keep food cold. Certain pharmaceutical agents or other medical products are desirably kept frozen, as well as are a variety of chemical reactants. In each of these cases, the improved impact properties of microcellular material make microcellular material particularly suited for storage in a freezer, and methods of storage of these articles in a freezer and articles including instructions for such storage are intended to be within the scope of the invention.

Where the microcellular article is an article for food storage, it can be provided in the shape of a container with an opening in combination with a cover fitted to the opening. The cover can be a lid also made of microcellular material that covers the opening and preferably sealingly engages the opening. The container can include an opening with a matching lid or can include an opening without a matching lid, the opening covered by a clear polymeric film such as that typically used to cover pre-prepared foods for cooking in a conventional oven or for rapid cooking in a microwave oven. These clear, polymeric films can sealingly engage container openings via heat activation, a heat-activated adhesive, or other means of adhesion. An accompanying cover can define a "snap-on dome", can be metal foil, such as aluminum foil, that conforms to the container opening, or the like.

The invention provides a microcellular article including instructions for storage of food in the article, such as instructions on a frozen food package or freezer box, or the article can include instructions for storage of the article in a freezer, for example as would accompany a frozen food product, ice tray, or container of pharmaceutical or chemical product desirably kept in a freezer or a freezer pack for a lunch box. The instructions can be printed directly on the container, printed on a label adhered to the container, printed on a box within which the container is stored and/or sold, or the like. The general public is familiar with instructions that accompany consumer products such as those described. The instructions also can include

instructions for heating the microcellular article to temperatures significantly above room temperature, for example, temperatures above about 200°F for periods of time exceeding 10-20 minutes. These instructions can be for cooking food within the article in a conventional oven at the temperatures and for the times indicated herein, or for cooking food in a microwave oven under conditions given a comparable result in the food product. One advantage associated with food containers having good high-temperature and low-temperature impact properties is that the containers are useful for packaging and selling frozen foods, such as pre-prepared dinners, that can be stored in a freezer and removed from the freezer and placed directly into a conventional or microwave oven in which the food is heated or cooked. Accordingly, in one embodiment of the invention, a microcellular article is provided including instructions for storage of the article at a temperature below 40°F, 32°F, or lower as described above, for example storage in a freezer, and for placement of the article in a conventional or microwave oven, optionally directly after removal from low-temperature conditions. Cooking conditions can involve heating the microcellular article in a conventional oven to a temperature of at least 250°F for a period of time of at least 15 minutes, or higher temperatures such as 375°F or 350°F for periods of time of at least 15 or 45 minutes. In connection with microwave cooking, the food may absorb microwave radiation and therefore be heated to a greater extent than the article. However, if the food is heated to cooking temperatures as described, at least a portion of the interior surface of the article will be heated to the same or nearly the same temperature.

Other combinations of heating and cooling to temperatures under conditions described above can be carried out in accordance with the invention, and the articles of the invention are particularly well-suited to multiple cycles of heating and cooling due to their good impact properties at both high and low temperatures. For example, one method of the invention involves storing a microcellular article at low temperatures, as described above. Another embodiment involves storing the article at low temperature, then subjecting the article to thermal conditions as described above in connection with ovens. In yet another embodiment the article is re-frozen after heating, and in yet another embodiment re-heated after re-freezing. In another set of embodiments the article can be exposed to conditions typical of an oven prior to freezing, that is, the article can be used as a container in which food is cooked, then the food can be frozen in the container and optionally re-heated and re-frozen any number of times. These methods, and articles including instructions for use in accordance with these methods,

are intended to be included in the invention. These methods, and articles including instructions for use in accordance with these methods, benefit from the shift to lower temperature of brittle/ductile transition temperature that occurs when the article is a microcellular article.

The function and advantage of these and other embodiments of the present invention will be more fully understood from the examples below. The following examples are intended to illustrate the benefits of the present invention, but do not exemplify the full scope of the invention.

Example 1: Impact Properties of Impact-Modified Polyethylene Terephthalate Article

Non-foamed, 0.95 I.V., homopolymeric polyethylene terephthalate (PET) containing linear, low-density polyethylene (~3.5%) and including conventional acrylic rubber impact modifier particles with compatibilizer (Rohm & Haas, Paraloyd™ EXL 53-75), was extruded as a sheet. The sheet was thermoformed in a heated mold to a crystallinity of at least about 20% and shaped as a food container having a flat bottom of approximately 30 mils thickness.

Impact properties (fracture energy; calculated as the area under the force/displacement curve generated) at low and room temperature were tested using an instrumented falling dart (Dynatup) test according to ASTM D3763-92 (high-speed puncture properties of plastics) using load and displacement sensors (19" drop height; 4 kg drop weight; dart = semispherical, 1/2" diameter tip; clamp opening = 1 1/2" diameter; holding clamp = 2 1/2" diameter; tests were conducted in an environmental chamber; samples were preconditioned for 24 hours prior to testing). At 72 °F, the material exhibited ductile behavior, specifically, the fracture energy of the material was 55.8 in·lb. At -20 °F, the material exhibited brittle behavior, specifically, the fracture energy of the material was 10.7 in·lb. These data reflect results averaged from 10 samples tested.

Example 2: Production and Impact Properties of Impact-Modified Microcellular Polyethylene Terephthalate Article

An extruded sheet essentially identical in material composition to the article of Example 1 was provided, and was processed in a batch microcellular processing chamber as

described with reference to Fig. 3 of U.S. Patent No. 5,158,986 (Cha), incorporated herein by reference, with the following details: The high-pressure chamber was maintained under 3000 psi CO_2 and 110 °F for approx. 30 hours. After removal of the article from the pressure chamber, the article was foamed in a water bath at 212 °F for approx. 30 sec. The resultant microcellular article had a void fraction of 50% and crystallinity of at least about 20%. Average cell size was approx. 5-10 microns. The final thickness was 37 mils.

Impact properties at low and room temperature were tested as in Example 1. At 72 °F, the material exhibited ductile behavior. Specifically, the fracture energy of the material was 50.5 in·lb. Surprisingly, at -20 °F, the material exhibited ductile behavior, specifically, the fracture energy of the material was 48.6 in·lb. These data reflect results averaged from multiple samples tested.

The result of this example demonstrates that the brittle/ductile transition temperature is shifted from above -20 °F when material is non-microcellular to below -20 °F when material is essentially identical but microcellular.

Example 3: Production and Impact Properties of Non-Impact-Modified Microcellular Polyethylene Terephthalate Article

An article essentially identical to the article of Example 2, but without impact modifier, was provided. Microcellular processing was carried out as in Example 2 resulting in material having crystallinity of at least about 20%, with the following exceptions. The article was foamed in an oil bath at approx. 300 °F for approx. 30 sec. The resultant microcellular article had a void fraction of 50%. Average cell size was approx. 5-10 microns. The final thickness was 33 mils.

Impact properties at low and room temperature were tested as in Example 1. At 72 °F, the material exhibited predominantly ductile behavior, specifically, the fracture energy of the material was 48.4 in·lb. Surprisingly, at -20 °F, the material exhibited ductile behavior, specifically, the fracture energy of the material was 38.6 in·lb. These data reflect results averaged from multiple samples tested.

The result of this example indicates that the brittle/ductile transition temperature of this non-impact-modified PET is shifted from above -20 °F when material is non-microcellular Example 1 to below -20 °F when the material is microcellular.

Summary of Examples

The examples above demonstrate that a non-foamed, PET, impact-modified extruded sheet shows room temperature ductile behavior, and low temperature brittle behavior while, surprisingly, the same material processed as a microcellular material exhibits ductile low-temperature behavior and, even more surprisingly, the same material processed as microcellular material and *absent* impact modifier exhibits low temperature ductile behavior. That is, the brittle/ductile transition temperature of polymeric material, when processed as microcellular polymeric material, is shifted downward to a range of below typical freezer storage conditions.

Those skilled in the art would readily appreciate that all parameters listed herein are meant to be exemplary and that actual parameters will depend upon the specific application for which the methods and apparatus of the present invention are used. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, the invention may be practiced otherwise than as specifically described.

What is claimed is:

CLAIMS

1. A method comprising:

storing food in a microcellular container at a temperature of less than about 32°F for a period of time of at least one day.

2. A method comprising:

storing a microcellular article at a temperature of less than about 40°F for a period of time of at least one hour.

3. A method as in any preceding claim, comprising storing the microcellular article at a temperature of less than about 32°F for a period of time of at least one hour.

4. A method as in any preceding claim, comprising storing the microcellular article at a temperature of less than about 20°F for a period of time of at least one hour.

5. A method as in any preceding claim, comprising storing the microcellular article at a temperature of less than about 40°F for a period of time of at least one day.

6. A method as in any preceding claim, comprising storing the microcellular article at a temperature of less than about 32°F for a period of time of at least one day.

7. A method as in any preceding claim, wherein the microcellular article is a container, the method comprising storing food in the microcellular container at a temperature of less than about 40°F for a period of time of at least one hour.

8. A method as in any preceding claim, comprising storing food in the microcellular container at a temperature of less than about 32°F for a period of time of at least one hour.

9. A method as in any preceding claim, wherein the microcellular container is a polymeric microcellular container having good low-temperature impact resistance relative to a similar container made of material essentially identical except being non-microcellular.

10. A method as in any preceding claim, further comprising cooking the food in the container.

11. A method as in any preceding claim, wherein the cooking step involves heating the food and the container in an oven at a temperature of at least 250°F for a period of time of at least 10 minutes.

12. A method as in any preceding claim, wherein the cooking step involves cooking the food in a microwave oven.

13. A microcellular article in the shape of a container with an opening in combination with a cover fitted to the opening.

14. A microcellular article in combination with instructions for storage of the article at a temperature below 32°F.

15. A method or article as in any preceding claim, wherein the article is a polymeric article.

16. A method or article as in any of claims 13-15 wherein the cover is a lid that sealingly engages the container opening.

17. A microcellular article as in any of claims 13-16 wherein the cover is a plastic film that sealingly engages the container opening by being adherent to the portion of the container defining the opening.

18. A method or article as in any preceding claim, further comprising instructions for storage of food in the article.

19. A method or article as in any preceding claim, further comprising instructions for storage of the article in a freezer.

20. A method or article as in any preceding claim, further comprising instructions for

placing the article in an oven.

21. A method or article as in any preceding claim, wherein the microcellular article has an average cell size of less than about 100 microns.

22. A method or article as in any preceding claim, wherein the microcellular article has an average cell size of less than about 25 microns.

23. A method or article as in any preceding claim, wherein the microcellular article has an average cell size of less than about 10 microns.

24. A method or article as in any preceding claim, wherein the microcellular article has an average cell size of less than about 6 microns.

25. A method or article as in any preceding claim, wherein the microcellular article has a maximum cell size of about 100 microns.

26. A method or article as in any preceding claim, wherein the microcellular article has a maximum cell size of about 30 microns.

27. A method or article as in any preceding claim, wherein the microcellular article has a maximum cell size of about 15 microns.

28. A method or article as in any preceding claim, wherein the microcellular article is essentially closed-cell.

29. A method or article as in any preceding claim, wherein the microcellular article contains auxiliary impact modifier.

30. A method or article as in any preceding claim, wherein the microcellular article is free of auxiliary impact modifier.

31. A method or article as in any preceding claim, wherein the material is PET.

32. A method or article as in any preceding claim, wherein the article is a PET microcellular article.

33. A method or article as in any preceding claim, wherein the polymeric microcellular container is a thermoplastic microcellular container having heat resistance of at least 100°C.

34. A method or article as in any preceding claim, wherein the microcellular container comprises polymeric material selected from the group consisting of PET, polypropylene, high-impact polystyrene, and maleic anhydride co-polystyrene.

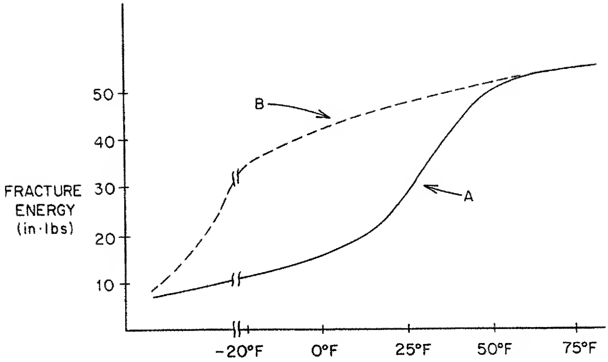

FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/13268

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B65D65/38 B65D81/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
A	US 4 728 559 A (HARDENBROOK) 1 March 1988 see column 1, line 26 - line 41 see column 2, line 47 - column 3, line 32 see column 4, line 6 - line 19; figures 1,2	1,2,13
A	US 5 158 986 A (CHA) 27 October 1992 cited in the application see column 1, line 16 - column 3, line 30 see column 9, line 26 - column 10, line 4; figure 17	13
A	US 4 473 665 A (MARTINI-VVEDENSKY) 25 September 1984 cited in the application	
A,P	WO 98 08667 A (TREXEL) 5 March 1998 cited in the application	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 October 1998	21.10.98

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Martens, L

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/13268

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 89 00918 A (MIT) 9 February 1989	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 98/13268

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 14
because they relate to subject matter not required to be searched by this Authority, namely:
The subject-matter of claim 14 has not been searched in virtue of Rule 39.1.v PCT

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/13268

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4728559 A	01-03-1988	NONE	
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		JP 2625576 B	02-07-1997
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WO 8900918 A	09-02-1989	EP 0377650 A	18-07-1990
		US 5160674 A	03-11-1992